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SESSION TOPIC: THREATS AND TARGETS
HERA: THREAT REPLICATION COVERING THE SPECTRUM OF TMD TARGETS

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Abstract

Development of Theater Missile Defense (TMD) systems requires testing against threat representative targets which fulfill specific test objectives for both the individual test and the overall program. The specific target parameters of interest vary depending on the phase and maturity of the interceptor or sensor program. The target provides the linkage between actual threats and interceptor testing. The flexible Hera delivery system and modular design provide the capability to match evolving threats including generic Tactical Ballistic Missiles (TBMs), exact threat replicas, and complex payloads. Threat replication capability includes: kinematics, signature, dynamics, physical properties, payloads, and lethality. In addition to providing a varying level of stressing engagement parameters, the extensive Hera instrumentation suite provides real-time telemetry data to confirm accomplishment of specific interceptor mission flight test objectives.

Flexibility is provided via mission kits such that individual missions can be tailored to fit particular interceptor mission requirements.

This paper presents the Hera threat replication capability which covers the spectrum of TMD targets. An example of the mission planning process to provide a tailored target mission for specific objectives is presented.

1.0 Introduction

To complete the development of advanced TMD systems and ensure their effectiveness against increasingly sophisticated threats, test missions must be conducted against TBM targets. The target systems used in these essential tests must possess the flexibil-

ity to cover the spectrum of threats at available test ranges, and must meet certain economical and reliability criteria. The Hera target system, developed by Coleman Aerospace Company (CAC) under contract to USASSDC, does so. Hera's modular design provides a variety of target types to match existing and evolving threats including generic TBMs, exact threat replicas, FMAs(Foreign Military Assets), and complex payloads. Threat replication capabilities include: kinematics, signature, dynamics, physical properties, payloads, and lethality. Onboard instrumentation provides the necessary data to allow assessment of the test results. The progression of target system capabilities, from the minimum to the most complex (Figure 1.0-1), generally follows the interceptor program maturity.

The Hera target system has evolved to cover a broad spectrum of capabilities. Hera enables the user to select appropriate mission-peculiar kits (which meet particular test objectives) while providing the benefit of proven reliability, flexibility, and accuracy. Each of the configurations in Hera's current available target

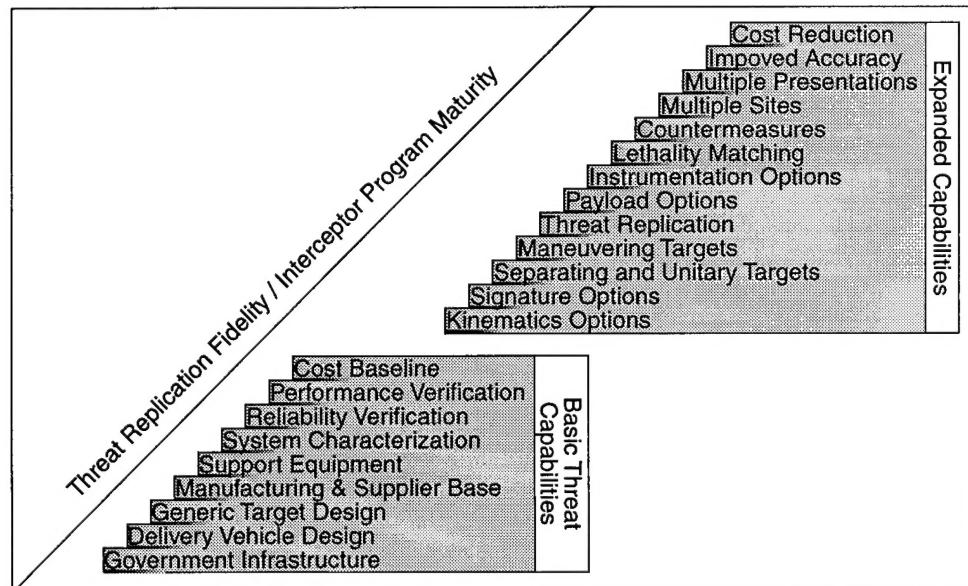


Figure 1.0-1. Hera target system capabilities allow flexibility to tailor individual target configurations easily.

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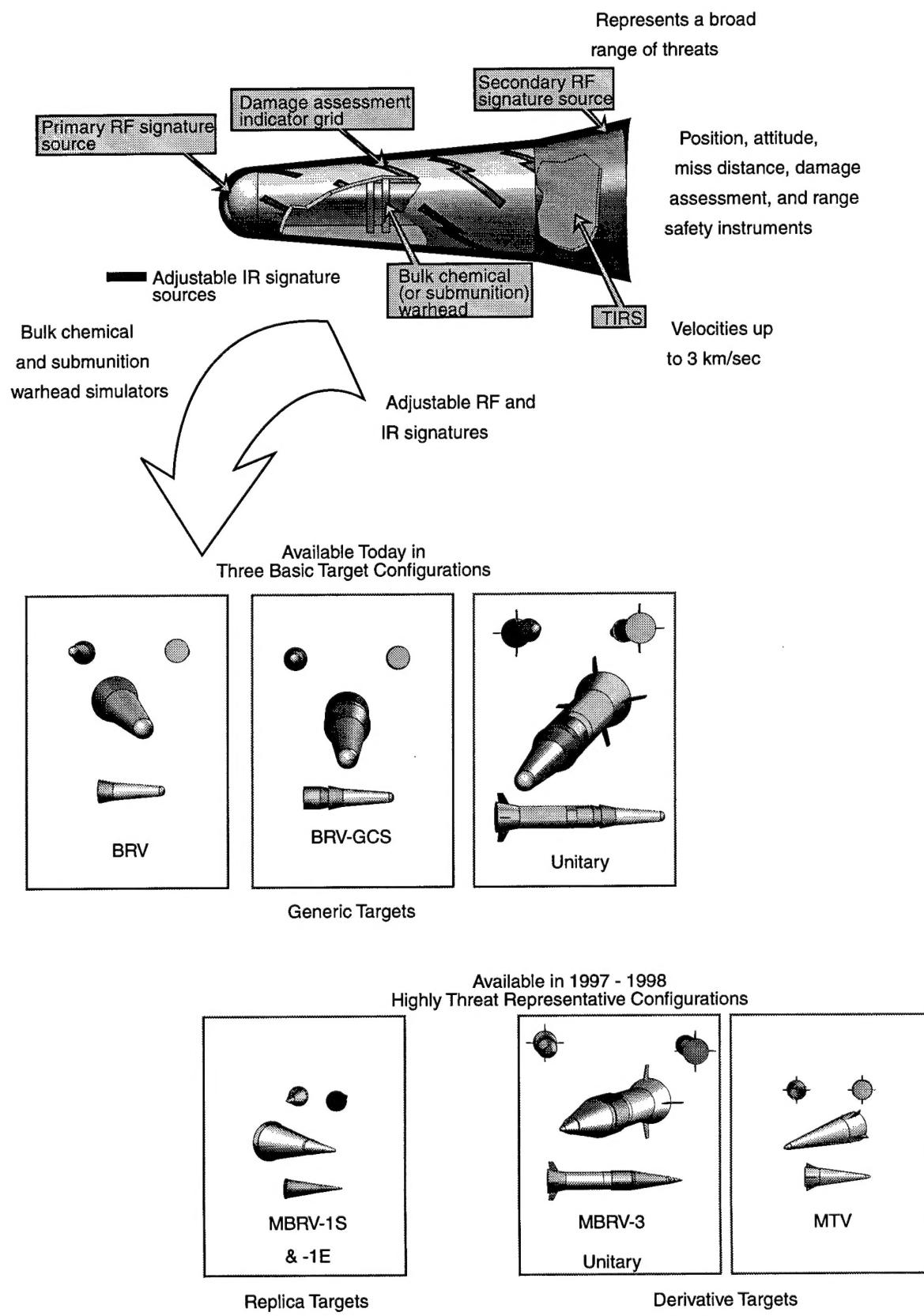


Figure 1.0-2. A wide variety of TMD threats can be simulated with Hera targets.

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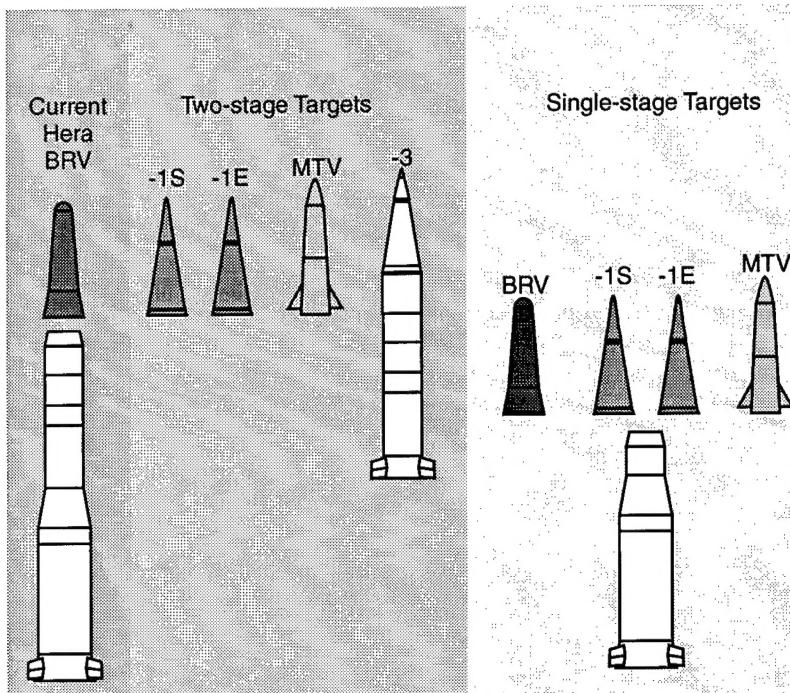


Figure 1.0-3. Hera provides a wide variety of TMD Targets.

suite (Figures 1.0-2 and 1.0-3) is designed to provide those capabilities described in Figure 1.0-1. By using a common delivery system, in combination with varying performance, test site, and instrumentation capabilities, multiple target types are easily provided. This approach meets the requirement for the targets needed to test today's multiservice TMD interceptors—especially in light of the aggressive development of these interceptors at different maturity and performance levels. The basic Hera target system can be easily tailored to suit missions ranging from the simplest to the most complex with the addition of kits or alternate front ends. This allows for the full spectrum of test scenarios and objectives with the target boosters, avionics, ground support equipment, and flight safety hardware common over these wide ranging missions.

1.1 Threat Replication Approach

The TMD threat definition covers TBMs with ranges of 70 to 3000 kilometers with corresponding kinematics, dynamics, and signature characteristics. These threats have specific physical properties, payloads and lethality capabilities.

The Hera target family provides generic threat-class targets, derivative targets that consist of GFE and FMA hardware, and threat specific replicas, all delivered with common boosters, avionics and ground support equipment. The current available target suite includes three generic versions, two derivative versions, and two replica versions as shown in Figure 1.1-1. The generic targets are derived from the STORM Ballistic Reentry Vehicle (BRV). The derivatives use Pershing II, Minuteman and FMA assets; while the replicas are modifications to lethality RVs based on MSIC threat data. The -1, and -3 nomenclature denotes different reentry vehicles or unitary configurations which correspond to specific classified threat types. The -3 unitary configuration uses an FMA RV. The Maneuvering Target Vehicle (MTV) and FMA unitary configuration are considered derivative targets. They are derived from existing flight proven hardware and are representative of the TBM class. Differences result from flight test requirements and use of existing hardware including the GFE booster and Pershing II RV. These physical differences create signature differences, which are fully characterized and quantified before flight. Figure 1.1-2 presents the -3 unitary configuration. Figure 1.1-3 presents the MTV configuration.

The replicas are designed with the threat external dimensions, shape and materials, thus supplying an excellent sig-

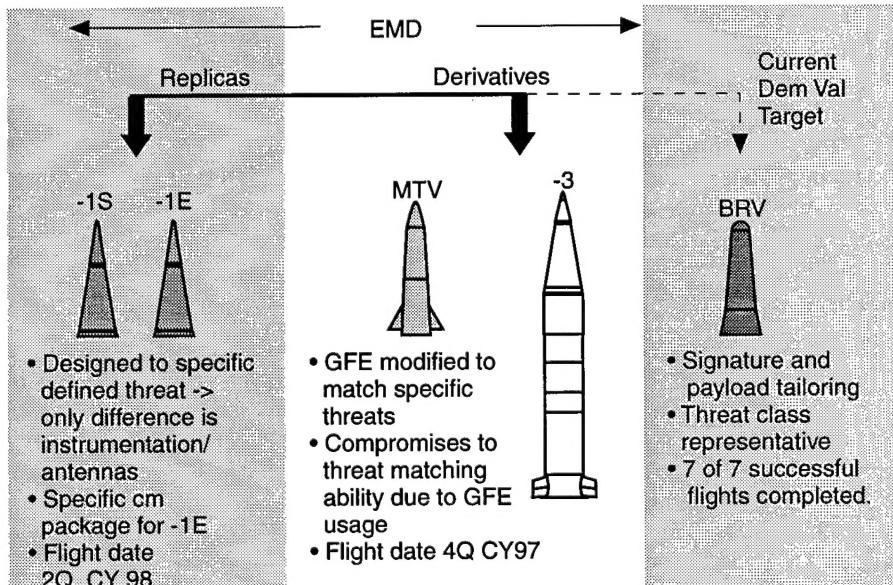


Figure 1.1-1. Hera provides replicas, derivative, and generic targets for the spectrum of TMD testing.

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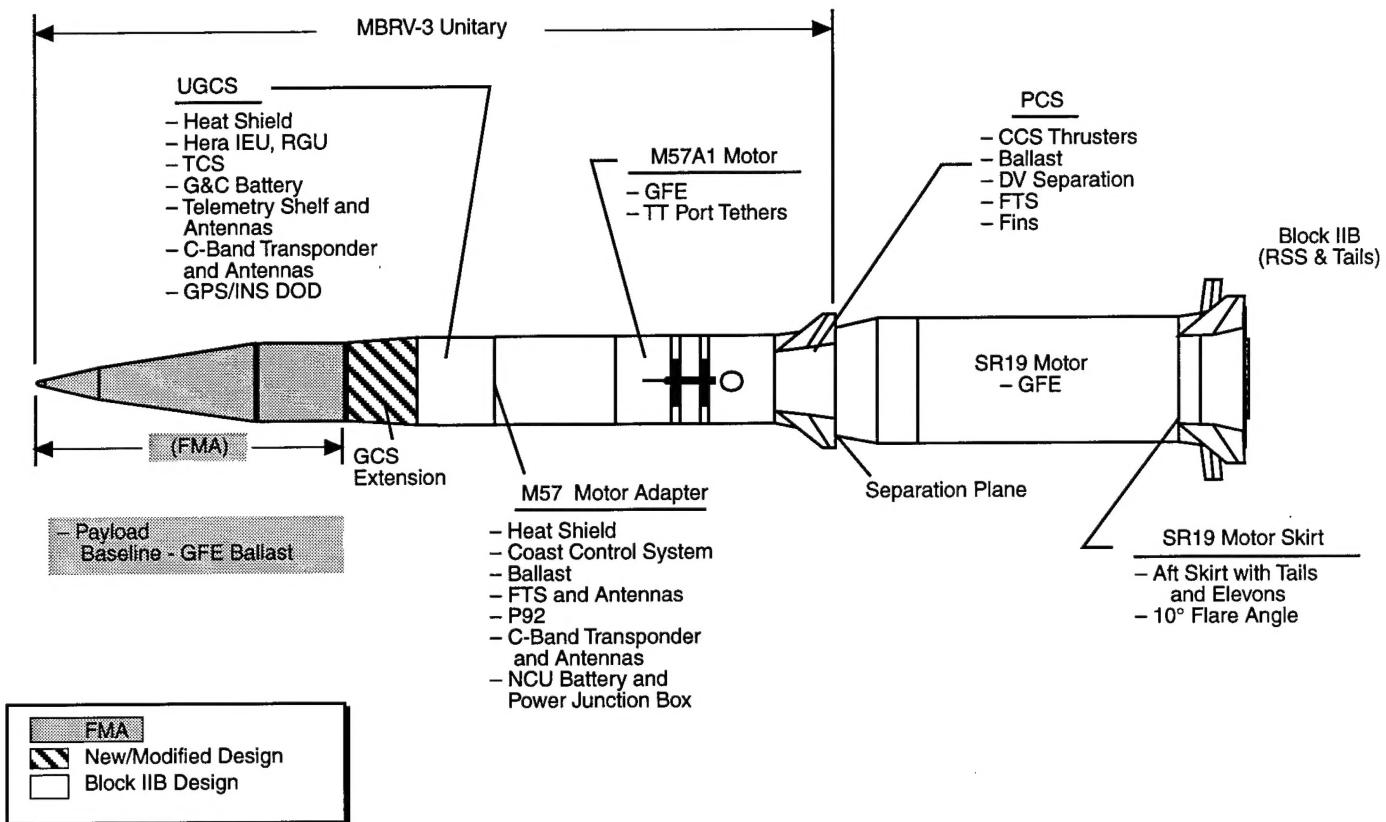


Figure 1.1-2. Unitary Configuration Summary

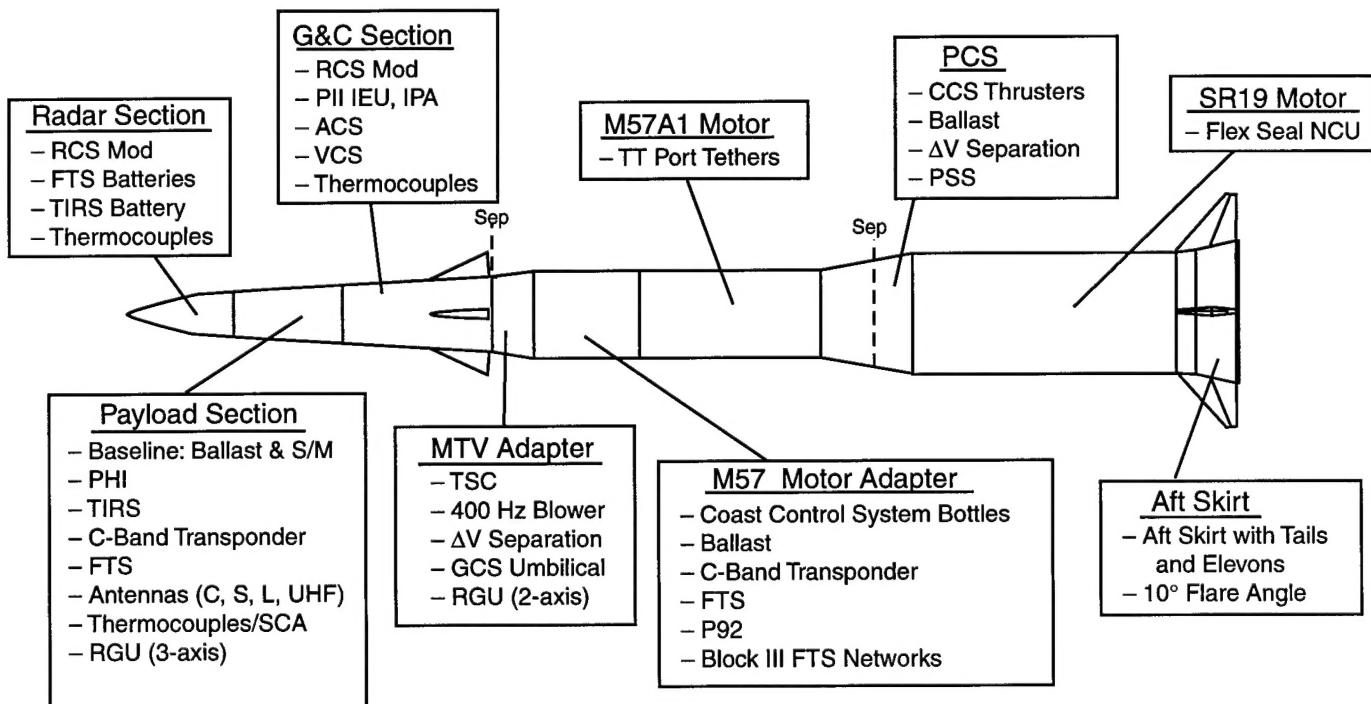


Figure 1.1-3. MTV Configuration Summary

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nature, lethality, and physical properties match. The 'E' version incorporates a specific CM package. Differences between the replica targets and threats result from flight test range requirements, range safety antennas, and instrumentation. Figure 1.1-4 presents the two-stage -1 configuration.

The current demonstration/validation target, BRV, represents the generic TBM threat class. Wide signature tailoring is possible via infrared (IR) skirts and Radar Cross Section (RCS) modifications. Special maneuvers and countermeasures have been flight proven for the BRV target. It is fully characterized. Figure 1.1-5 presents the BRV configuration.

Countermeasures capability exists for all configurations including flight proven dispense of penaids and maneuver capability.

Why is it necessary to provide replica targets? To date, the desire has been to use GFE or other existing designs where practical for economic reasons. However, as the interceptor programs mature, it is necessary for EMD and Operational testing to demonstrate the weapon system's capability to defend against a threat credible target. Replicas and FMA's satisfy the interceptor requirements for a high fidelity, threat representative target. Thus, a combination of target types is employed for the specific interceptor program; again allowing for development of additional replica types, adding signature or other kits to the existing targets, or incorporating additional FMA's as the threat evolution and priorities dictate. Consequently, the Hera program focus has evolved from providing only generic type targets to the current family in response to the needs of the various interceptor programs.

One essential aspect of threat replication is the flexibility to modify existing targets for updated threat assessments, and to incorporate new threat replicas or FMA's, as appropriate. This requires common subsystems that can be adapted to new designs with minimum change. Also, since threat evolution and interceptor test program objectives change very rapidly, it requires quick adaptation to requirement changes. In fact, the everchanging target requirements environment is one of the most challenging aspects of providing TMD targets. This is what prompted CAC to take the kit approach to provide specific users the necessary flexibility and options for testing.

1.2 System Design

Figure 1.2.1-1 shows the Hera target system. It consists of the Target Air Vehicle Equipment (TAVE), Transporter/Erector (T/E), Launch Stool, Launch Op-

erations Trailer (LOT), and Telemetry Ground Station (TGS). The TAVE uses a single- or two-stage Minuteman booster stack. Guidance is furnished by surplus Pershing II guidance and control hardware and software, or a CAC developed Global Positioning System/Inertial Navigation System (GPS/INS) system. The TAVE is launched from a fixed launch stool using trailer- or blockhouse-located launch equipment to control and monitor the launch preparation and countdown. The LOT is capable of counting and launching two missiles simultaneously, thus dual target engagements can be provided with the appropriate launch stool and range assets. The primary problem for multiple target and interceptor engagements is Radio Frequency (RF) spectrum management for flight safety, C-band tracking, and telemetry. The TAVE is assembled and transported to the launch pad using a modified GFE T/E.

Hera has been flown seven times with seven complete successes. Figures 1.2-2, -3 and -4 show the configuration specifics of the flights and an overlay of the first-stage nozzle commands and body rates. The wide variety of configurations, piggyback experiments, and kits flown is evident in the figures as well as the robust and repeatable performance of the SR19 control system and CAC autopilot.

The construct of the system allows for incorporation of additional RVs as the threat evolves, as well as incorporation of additional or alternate motor stacks for longer range TMD/National Missile Defense (NMD) targets.

Hera flight software design is flexible and easily tailored via mission-specific constants to satisfy a wide variety of specific trajectories. Through mission specific constants (presets) the flight and launcher software can be *programmed* to accommodate numerous missions and trajectories without modifying a single line of software. Presets provide the following capabilities:

- Numerous two-stage separating and non-separating conventional and Pile Driver trajectories with various flight path angles and velocities
- Launch site location selection
- Missile aim point selection
- Guidance with or without thrust termination
- Energy management maneuvers
- Presentation of a preflight programmed target object map (TOM) containing up to three objects.

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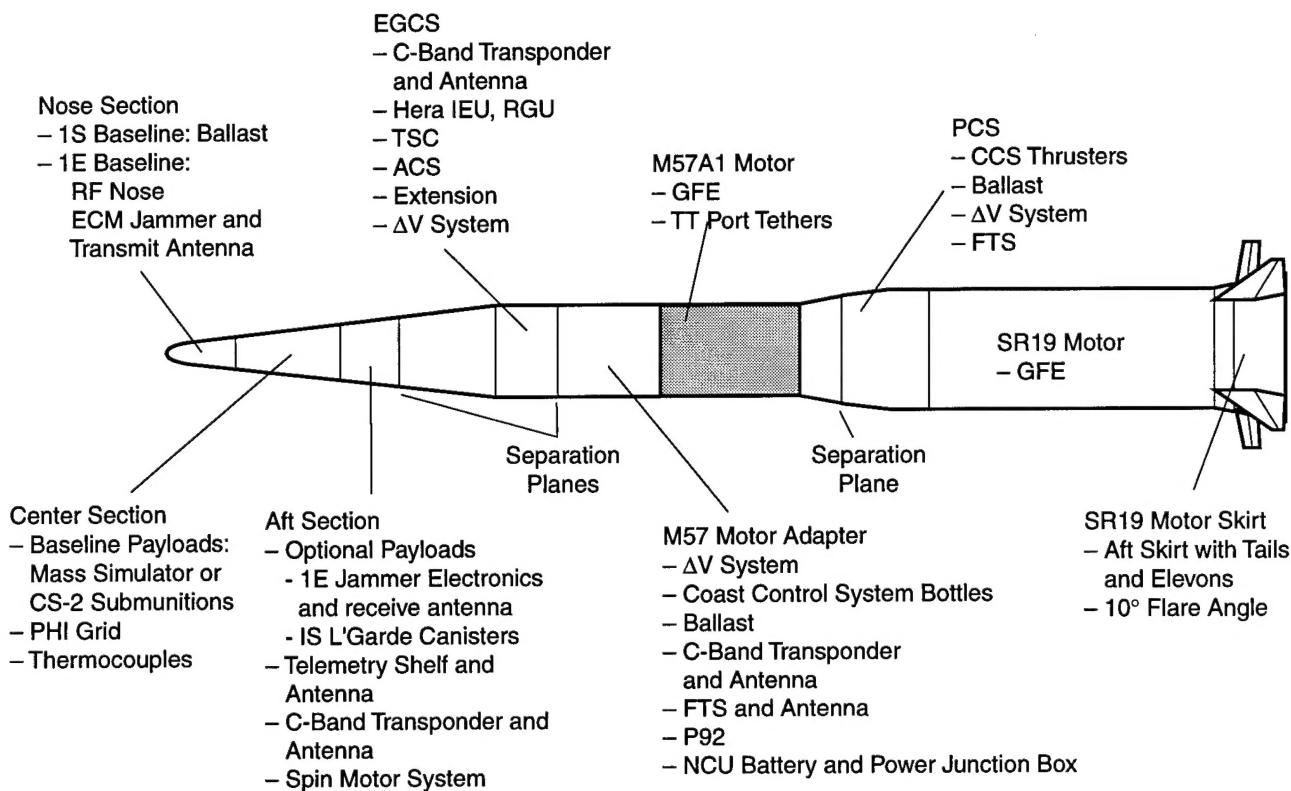


Figure 1.1-4. -1 Two Stage Configuration Summary

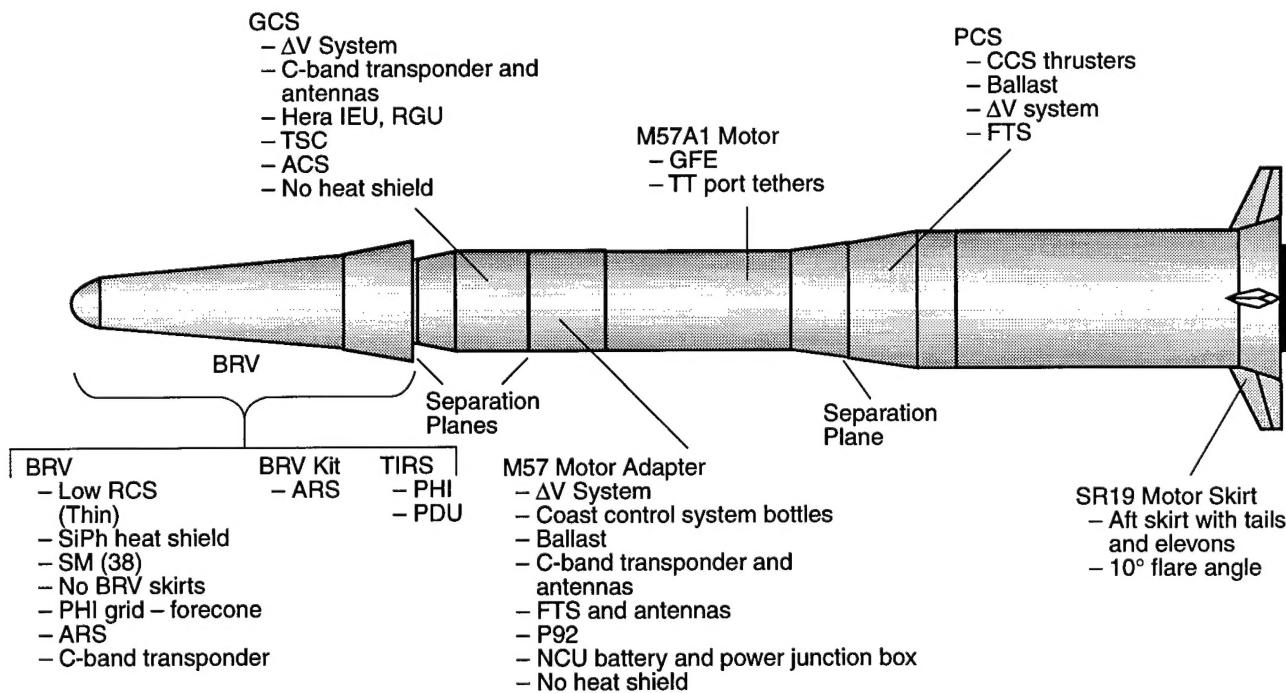


Figure 1.1-5. BRV Configuration Summary

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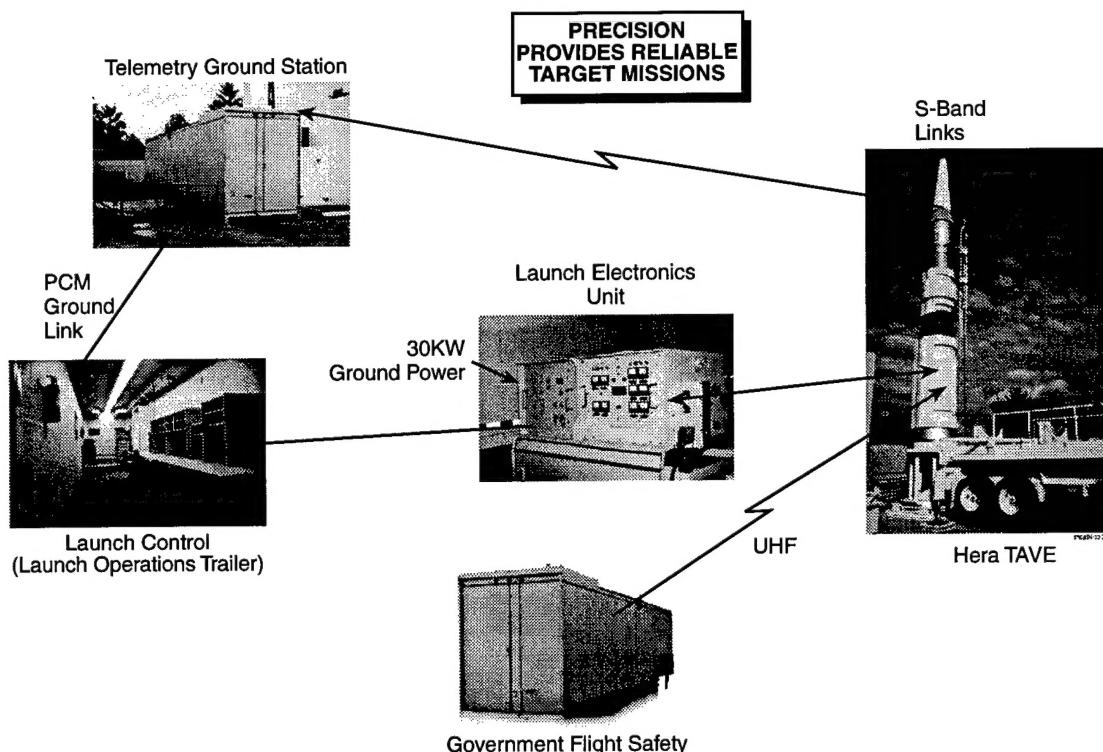


Figure 1.2-1. Hera TMD Target System Components

Flight	1	2	3	4	5	6	7
Target Number	1	2	3	5	6	8	7
Results	Success	Success	Success	Success	Success	Success	Success
Backup Target Number	N/R	N/R	N/R	N/R	7	N/R	10
Mission Name	PTV Demo	Hera Demo	PD Demo	FT-05	FT-06	RST-1	FT-07
Date	4/24/94	10/2/95	2/2/96	3/22/96	7/15/96	10/9/96	Feb 97
Launch Site	LC32	LC94	LC94	LC94	LC94	LC94	LC94
Block	I	IIA	IIA	IIA	IIA	IIA	IIA
Objectives	Demo	Demo	Demo	Intercept	Intercept	Radar Tracking	Intercept
Trajectory	Conv D	Conv D	Pile Driver	Conv D	Conv D	Special	Conv D
Intercept Configuration	BRV/GCS	BRV/GCS	BRV/GCS	Unitary	Unitary	N/A	Unitary
Ground Impact Configuration	BRV	BRV	BRV/GCS	Unitary	Unitary	BRV	Unitary
Thrust Termination	Yes	No	Yes	No	No	No	No
TOM Maneuver	No	Yes	No	No	No	No	No
RV Type/Payload	BRV/H2O	BRV/TEP	BRV/H2O	BRV/H2O	BRV/H2O	BRV/H2O	BRV/H2O
RV Heat Shield	Acusil	Si Ph	Si Ph	Si Ph	Si Ph	Si Ph	Si Ph
RCS Nose	High	High	High	High	High	High	High
RV Skirts/Slots	No/No	Yes/No	No/No	Yes/Yes	Yes/Yes	No/No	Yes/Yes
PHI/MDI	No/No	Yes/Yes	No/No	Yes/No	Yes/No	No/No	Yes/No
RV Temperature/ARS	No/Yes	Yes/Yes	Yes/Yes	Yes/Yes	Yes/Yes	No/Yes	Yes/Yes
Payload Dispense/Ordnance	No/No	Yes/Yes	No/No	No/No	No/No	No/No	No/No
CCS	No	Yes	Yes	Yes	Yes	Yes	Yes
GCS/Motor Adapter Ablative	No	No	Yes	Yes	Yes	No	Yes
Second Stage Fins	No	No	No	No	No	No	No
RSS	No	No	No	No	No	No	No
Piggy Back Items	Viper	PSL Instrumentation	None	None	None	STFD Canister	None

Si Ph: Silica Phenolic
Conv: Conventional

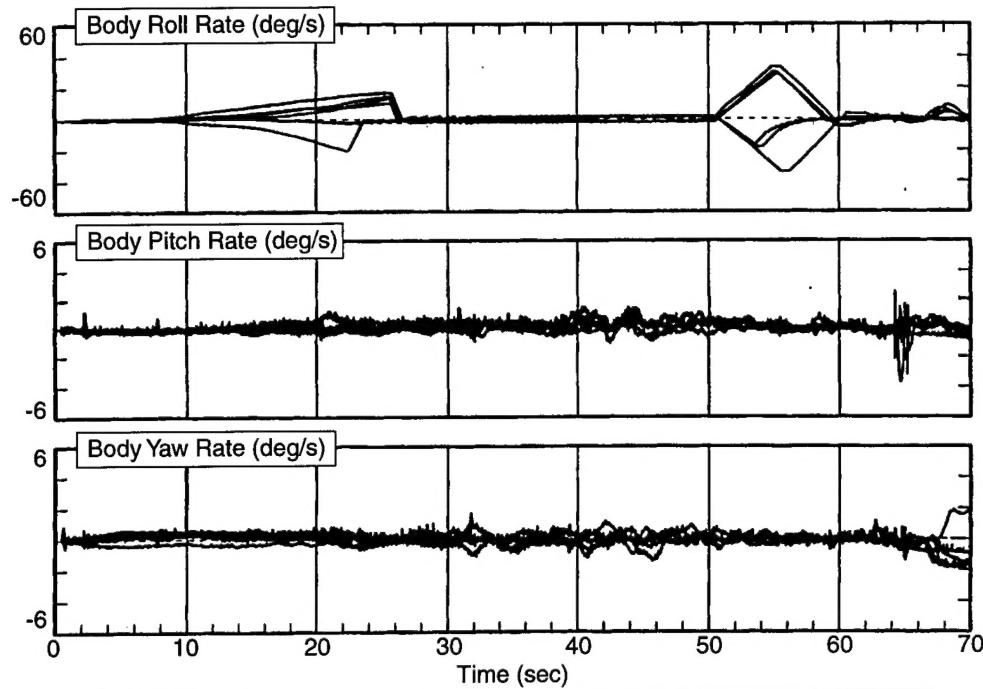
PD: Pile Driver
PHI: Photonic Hit Indicator

A variety of kits have successfully flown on Hera flights.

Figure 1.2-2. Hera Flight Matrix

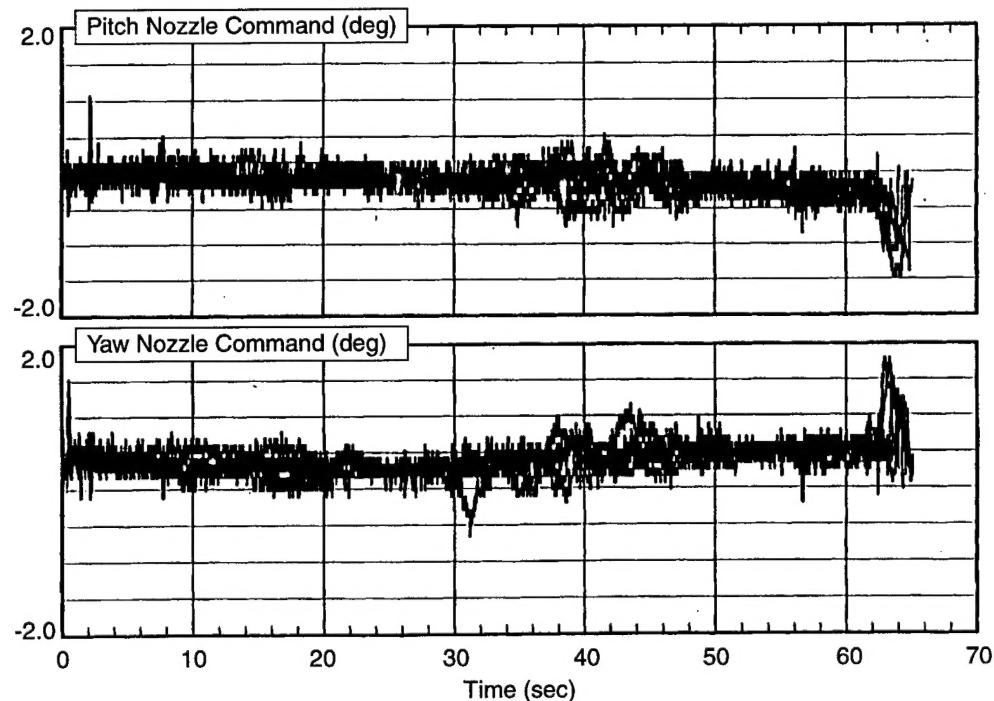
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Hera first stage boost flight control performance was consistent in all flights.

Figure 1.2-3. Time History of Hera Body Rates



Hera first stage boost flight control performance was consistent in all flights.

Figure 1.2-4. Time History of Hera TVC Commands

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- Payload dispense at preselected altitudes
- Various modes of exoatmospheric missile control
 - Coast Control System (CCS)
 - Attitude Control System (ACS)
 - Rate versus attitude.

Substantial margins on memory, throughput, and a flexible software design allow the addition of new capabilities without impacting existing functions. The software capabilities provide a quick response time and reliable software solution to mission requirements.

The kits available for specific mission tailoring are shown in Figure 1.2-5. This approach allows specific test objectives for a particular mission to be satisfied by: 1) inclusion or deletion of specific hardware elements in the target by selection of an appropriate kit; 2) test operation in a self-contained manner to allow testing at any test range or facility with minimum support required; 3) selection by software of a wide variety of trajectories; 4) tailoring RCS and IR signatures to the required level of threat matching by supplying either an FMA or a replica, derivative or tailored BRV; and 5) provision for ballistic and maneuvering targets and separating and unitary configurations with desired physical and material properties.

2.0 Hera Performance Capability

Hera provides ballistic or maneuvering trajectories over a 75- to 1140-kilometer range with velocities between 1.5 and 3.0 kilometers per second. The software design allows selection of a normal ballistic trajectory or extensive trajectory shaping (Pile Driver) by loading a set of software pre-sets unique to the mission.

Pile Driver trajectories furnish high velocity/low flight path angles from short flight ranges (75 to 160 kilometers). The Pile Driver, or shaped trajectory mission, directs the second-stage thrust vector in a downward direction providing for high-velocity shallow flight path angle engagement conditions which emulate the end game of a much longer range threat and permit testing at available overland test ranges. Figure 2.0-1 shows Hera top-level kinematic performance capabilities.

Figures 2.0-2 through -5 present two-stage Hera performance and events for the -3 unitary configuration from Ft. Wingate LC-96.

Figure 2.0-6 illustrates kinematic capabilities of other booster stacks to meet longer range mission requirements. Configurations for these longer range missions would use

a Hera subsystem and ground support equipment providing the longer range missions with the Hera system flexibility and kit approach.

3.0 Mission Planning Process To Meet User Objectives

The mission planning process encompasses a number of iterative steps to ensure that all desired objectives for a threat representative target flight test are met for the primary user. Figure 3.0-1 illustrates the mission planning process. This includes: deriving the mission requirements, identifying the target configuration, coordinating between the primary user and range safety, documenting via a Mission Requirements Letter, and providing performance prediction data including trajectory and signature to the primary and other users.

3.1 Tailored Mission Example

The modularity of the Hera target system and the ability to easily customize each mission configuration to meet interceptor and sensor objectives is illustrated in Figure 3.1-1. This example presents the -1 threat replica RV single- and two-stage configurations. This target emulates a short-range separating threat. If specific IR matching requirements are a test objective for the interceptor, the single stage provides a threat-like ballistic trajectory. Figure 3.1-2 presents the single- and two-stage trajectories. The single-stage trajectory combined with the matching physical properties, materials and dimensions of the replica RV yield a matching IR signature. Figure 3.1-3 shows the IR signature comparison for two stage and single stage. If the user has only RCS matching requirements, the RV replica dimensions and external materials provide the correct RCS; therefore, either the single- or two-stage configuration will satisfy the mission objectives.

4.0 Summary

The evolution of the Hera system to provide multiple target and scenario options permits individual user flexibility to tailor specific missions for the respective test objectives. The use of the basic Hera booster, avionics, flight safety, and telemetry hardware with available kits capitalizes on the Hera mission reliability, predictability and precision, and unmatched flight success. The Hera system design, including both airborne and ground elements, provides launch location and test range flexibility to accommodate a large number of test ranges currently envisioned for TMD testing, including Kwajalein Missile Range, White Sands Missile Range, Pacific Missile Range Facility, Kauai Test Facility, and Eglin Test Range.

The inherent flexibility of the system allows the addition of

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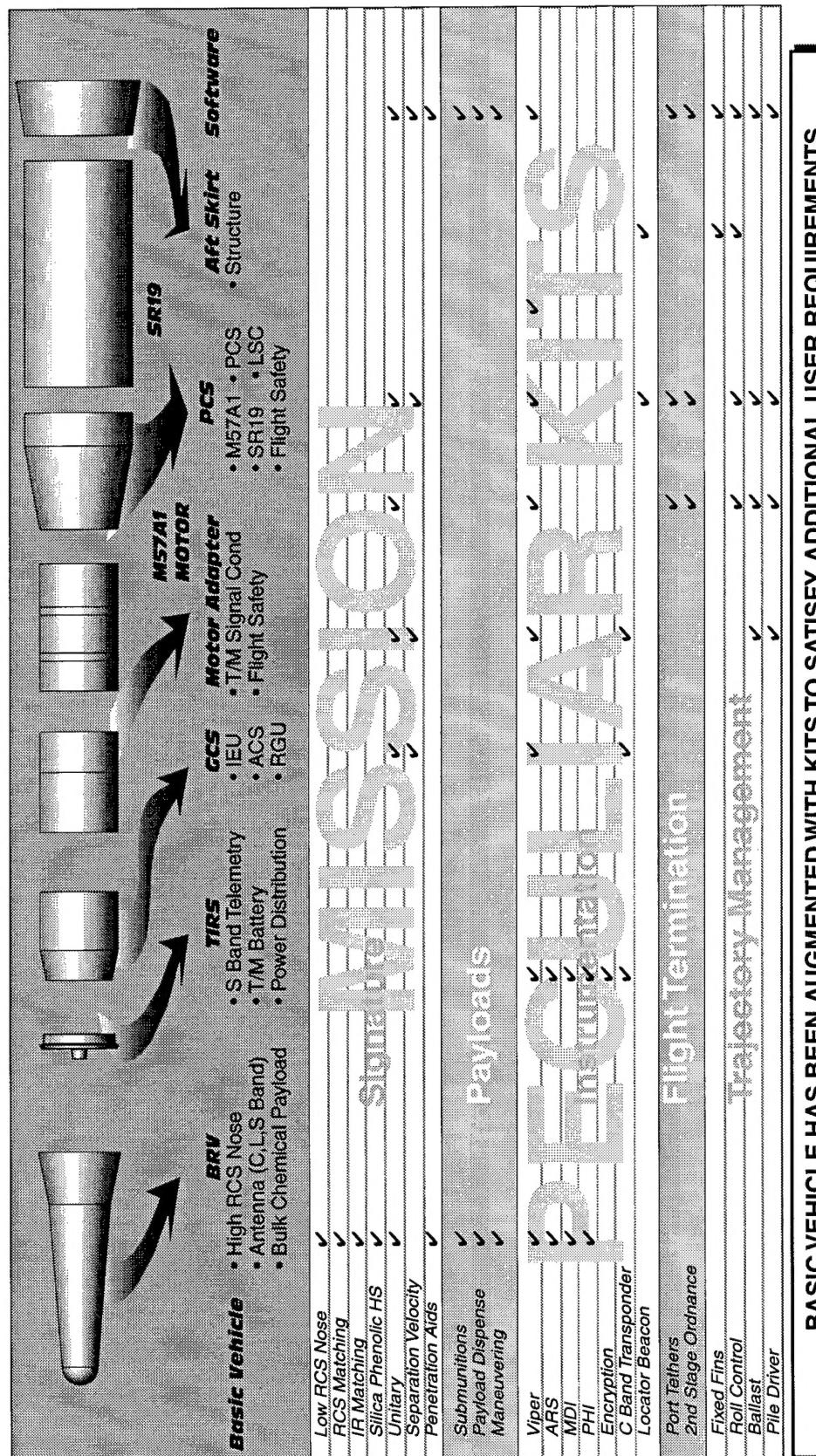


Figure 1.2-5. Hera Design Evolution

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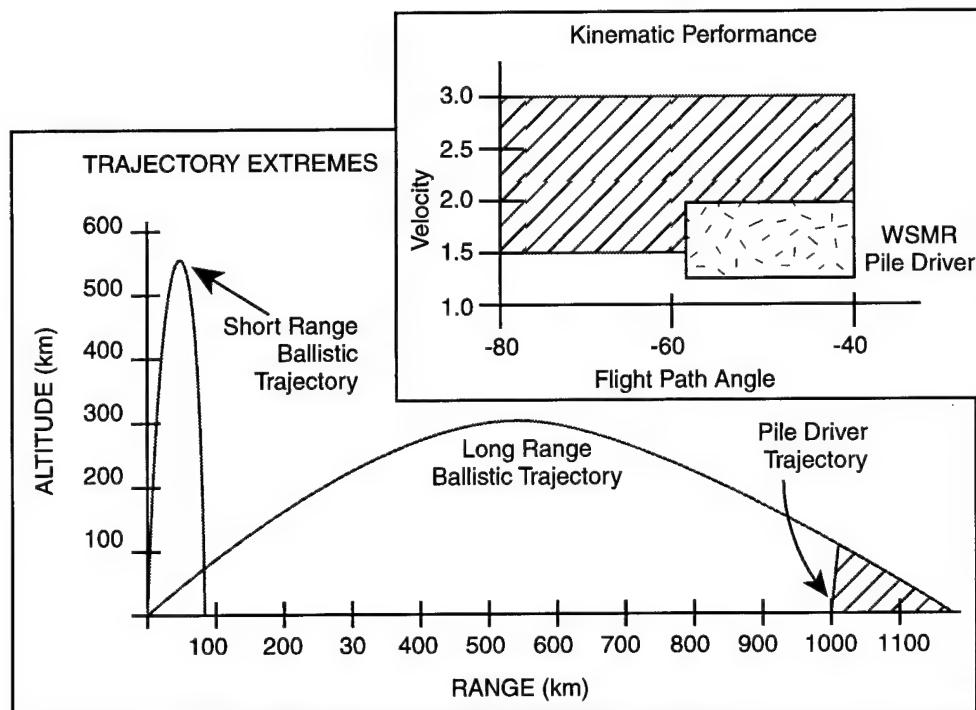


Figure 2.0-1. Hera Target Capabilities

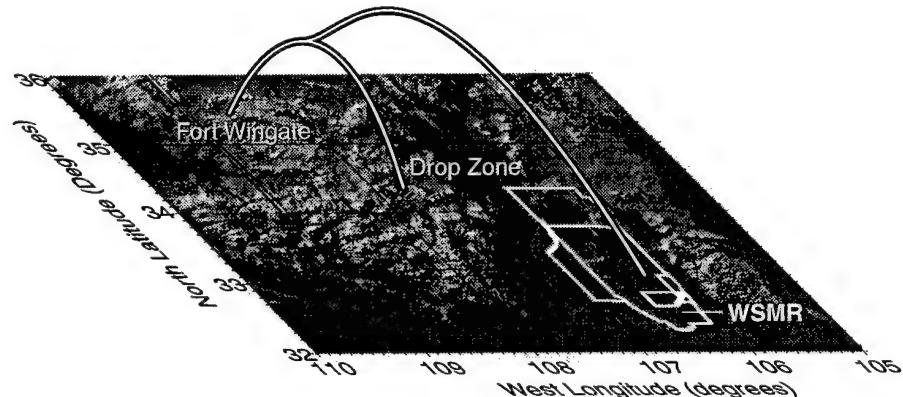


Figure 2.0-2. Fort Wingate to WSMR Mission Hera Two Stage Vehicles

threat types as they evolve and/or new threats become defined. The capability of the Hera system to deliver replicas, FMA's, derivative, and generic targets results in a target system capable of supporting current and future TMD testing.

The mission planning process with user and target provider participation allows for selection of the best combination of Hera kits and assets for the specific interceptor test mission objectives. The addition of other boosters, in combination with the proven SR19 and/or M57, provides low-risk, cost-effective growth to longer range missions.

Design flexibility and available subsystems make future

capabilities such as air launch, sea launch, additional countermeasures, new instrumentation, and additional launch sites easy to accommodate.

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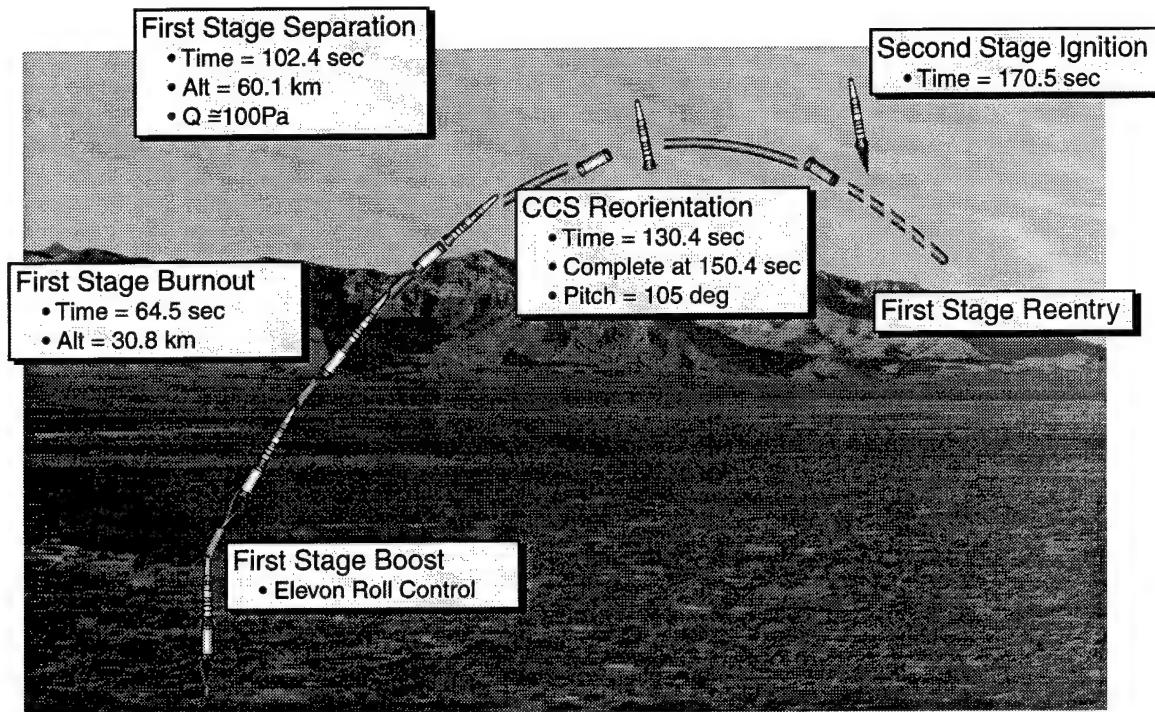


Figure 2.0-3. Fort Wingate Unitary Trajectory

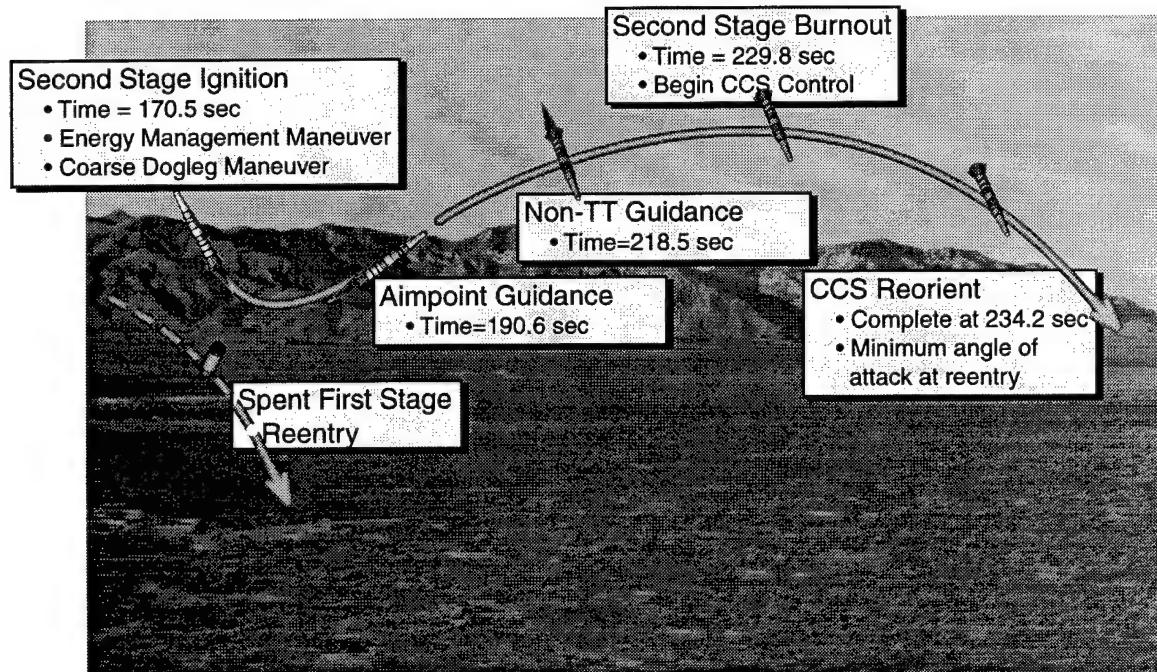


Figure 2.0-4. Fort Wingate Unitary Trajectory

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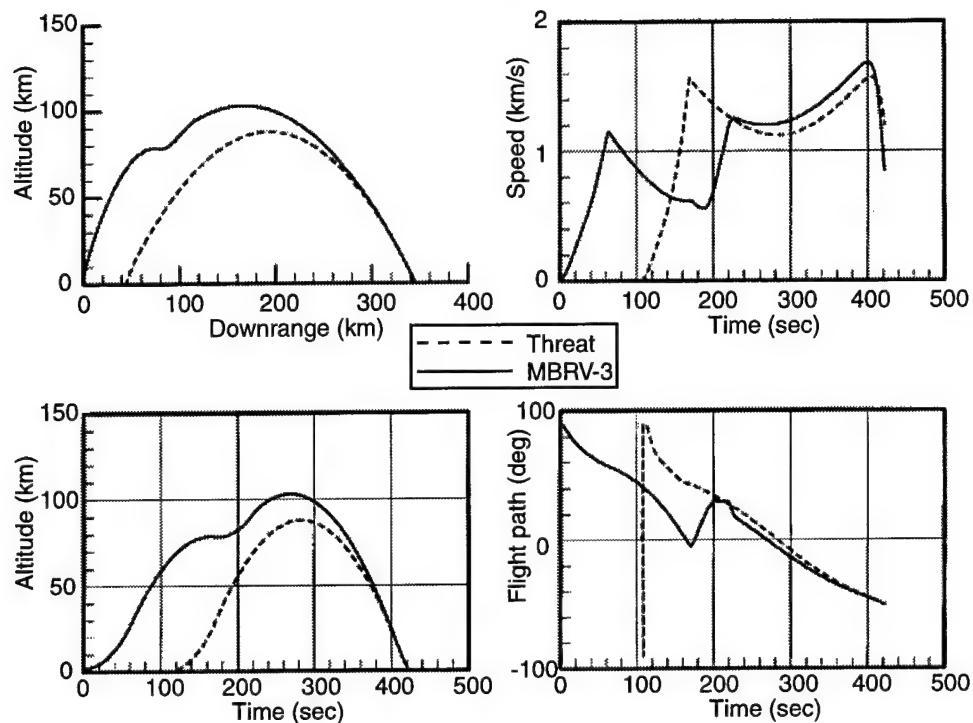


Figure 2.0-5. Fort Wingate Unitary Matching the Short Range Unitary Reference Trajectory

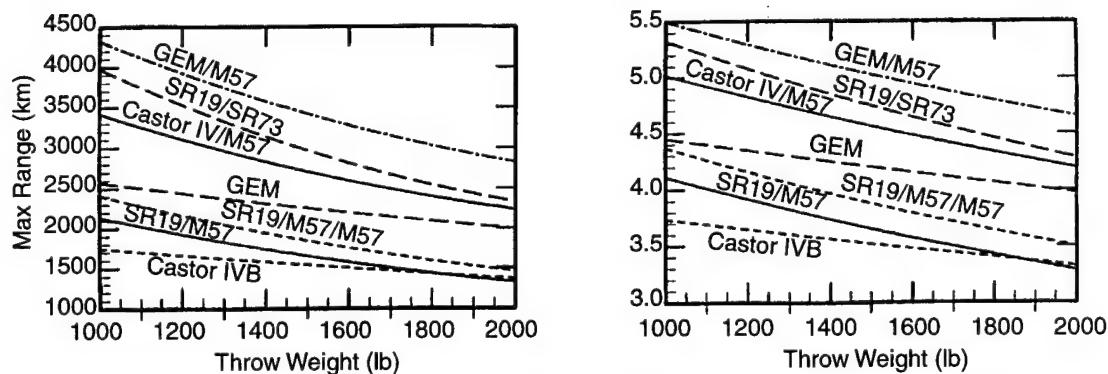


Figure 2.0-6. Range and Velocity Performance for Long-Range TMD Targets using Hera subsystems and modular kit approach.

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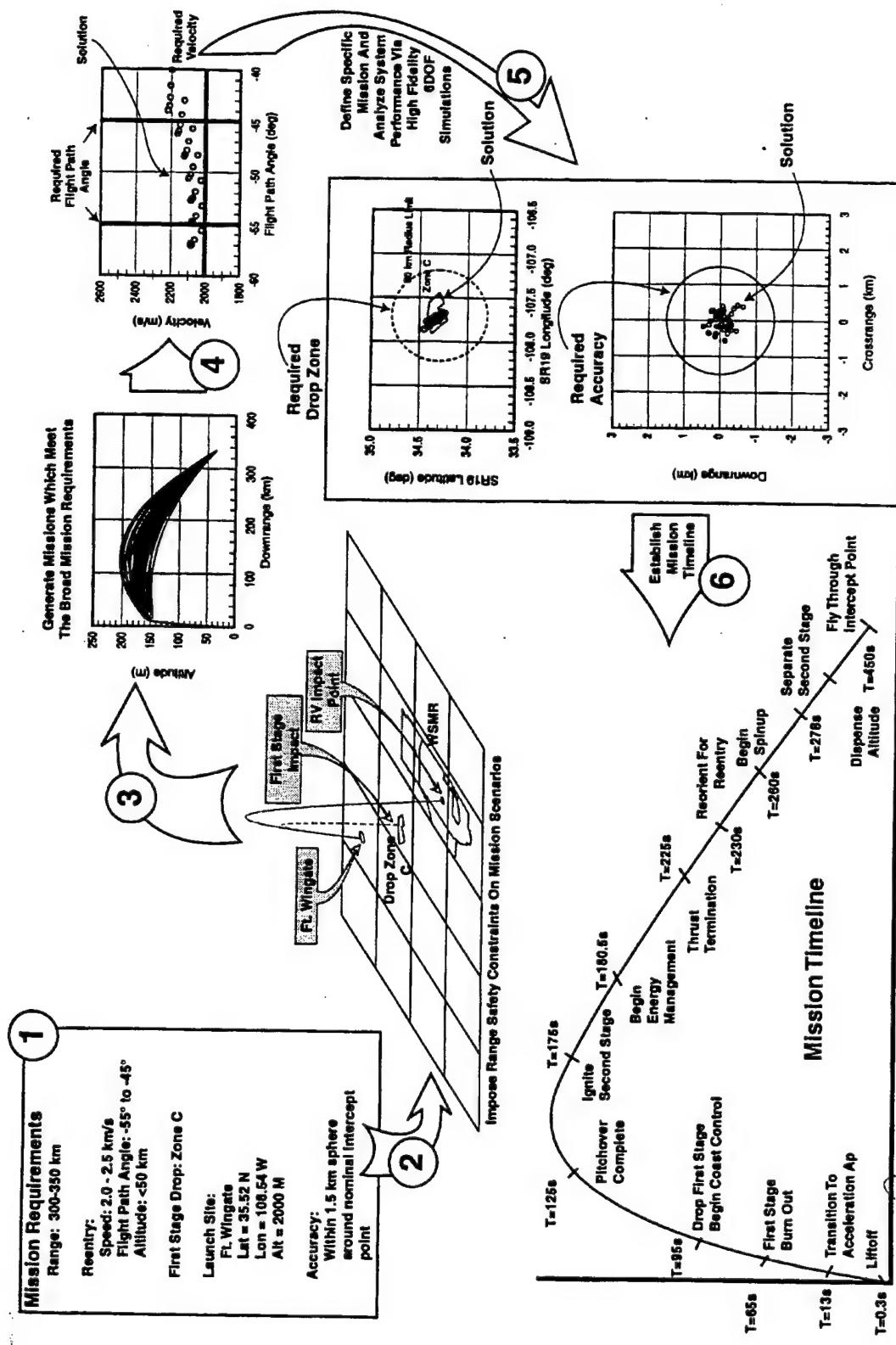


Figure 3.0-1. Mission Analysis Process

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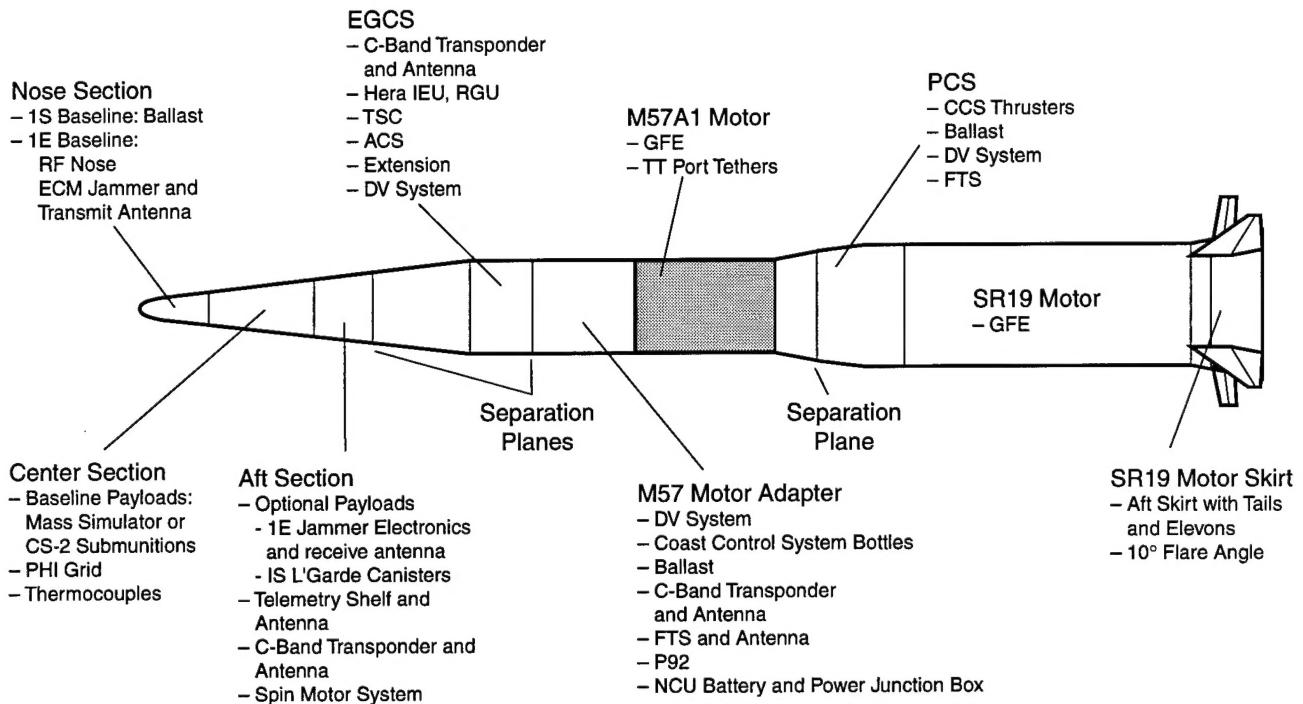


Figure 3.1-1(a). -1 Two Stage Configuration Summary

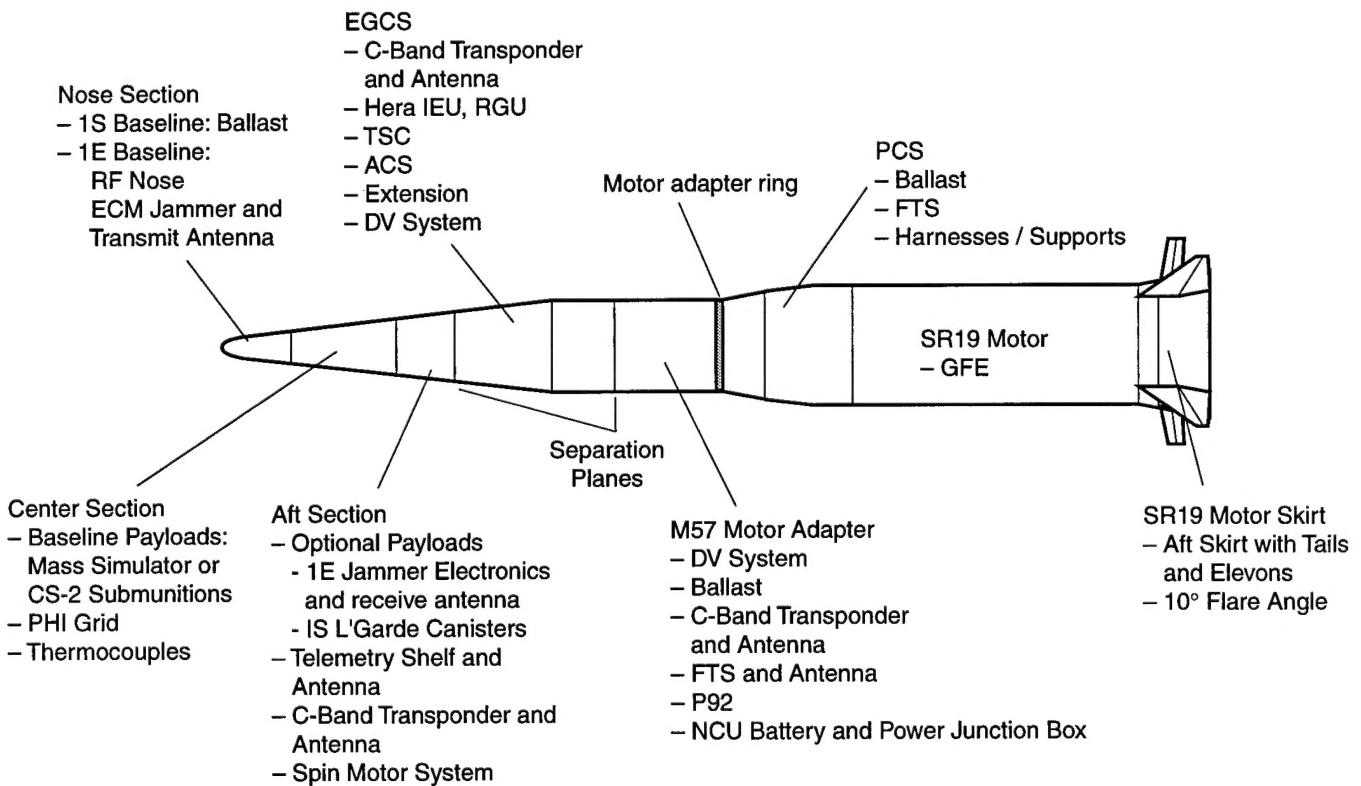


Figure 3.1-1(b). -1 Single Stage Configuration

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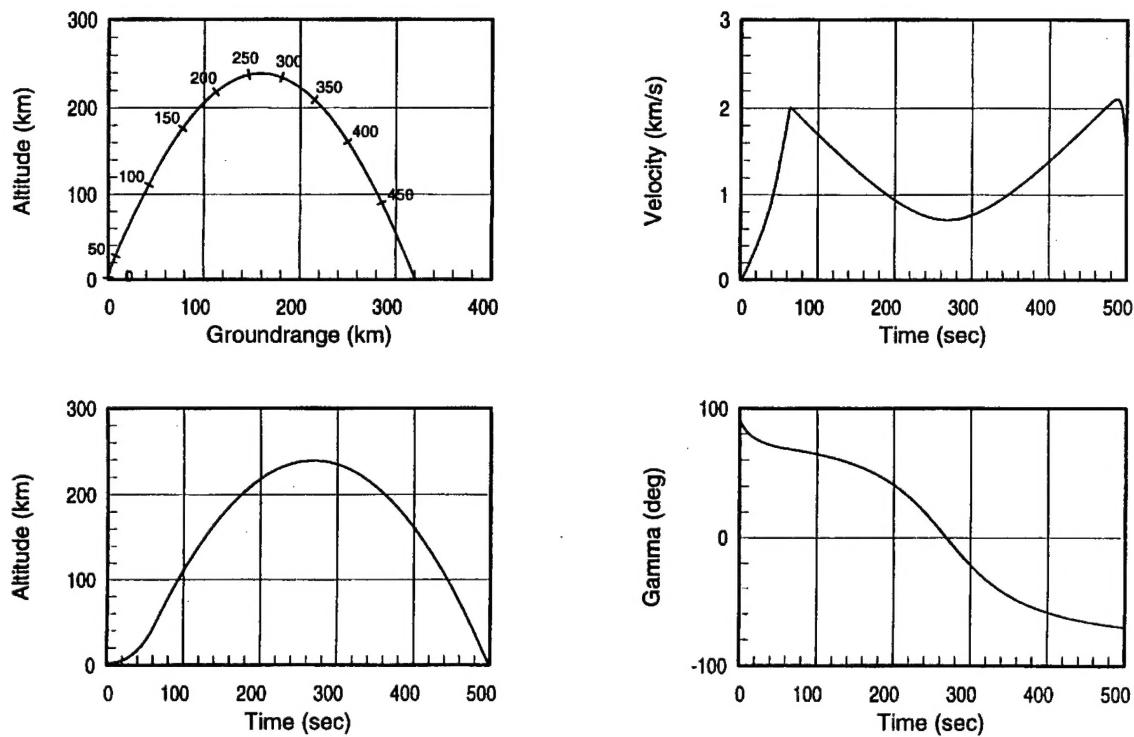


Figure 3.1-2(a). Hera Single Stage Launch

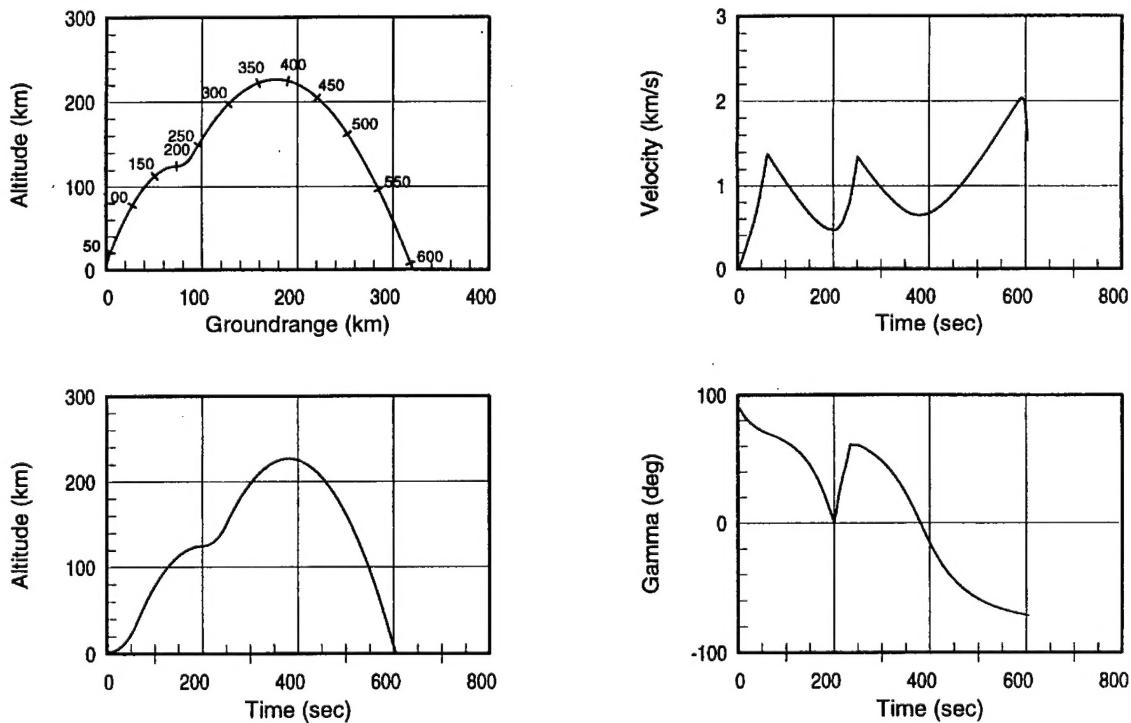


Figure 3.1-2(b). Hera Two Stage Launch

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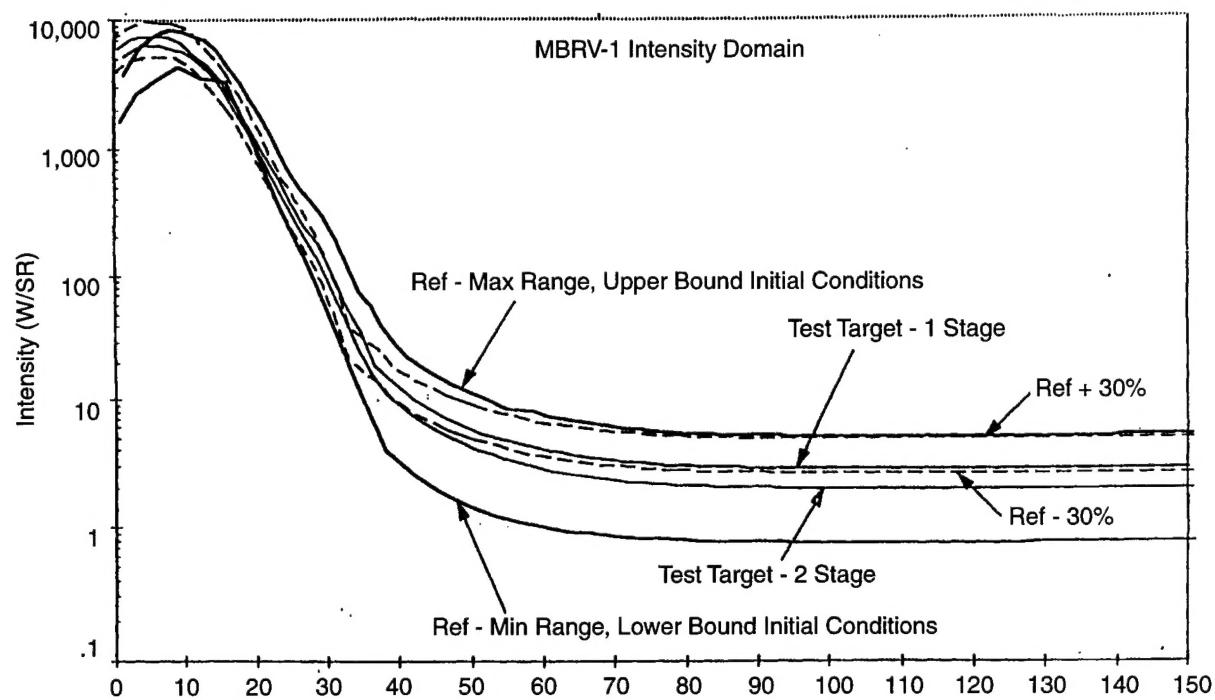


Figure 3.1-3. Two stage vs Single Stage IR Signature show the single stage provides a closer match to the threat

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ACS	Attitude Control System	PCS	Pile Driver Control Section
ARS	Attitude Reference System	PD	Pile Driver
ATP	Acceptance Test Procedure	PHI	Photonic Hit Indicator
BCE	Bulk Chemical Experiment	PTV	Preliminary Test Vehicle
BRV	Ballistic Reentry Vehicle	RCS	Radar Cross Section
CAC	Coleman Aerospace Company	RF	Radio Frequency
CCS	Coast Control System	RGU	Rate Gyro Unit
CHEFU	Clocked High Energy Firing Unit	RSS	Roll Stabilization System
CM	Countermeasures	RV	Reentry Vehicle
CRC	Coleman Research Corporation	SCA	Signal Conditioning Assembly
DV	Delivery Vehicle	SDU	STFD Dispense Unit
FMA	Foreign Military Assets	STFD	Simulated Tank Fragmentation Debris
FTS	Flight Termination System	T/E	Transporter/Erector
GCS	Guidance and Control Section	T/M	Telemetry
GFE	Government Furnished Equipment	TAVE	Target Air Vehicle Equipment
GPS	Global Positioning System	TBM	Tactical Ballistic Missile
IEU	Integrated Electronics Unit	TBM	Theater Ballistic Missile
INS	Inertial Navigation System	TGS	Telemetry Ground Station
IPA	Inertial Platform Assembly	TIRS	Telemetry, Instrumentation, and Range Safety
IR	Infrared	TLM	Telemetry
LOT	Launch Operations Trailer	TMD	Theater Missile Defense
MBRV	Modular Ballistic Reentry Vehicle	TOM	Target Object Map
MDI	Miss Distance Indicator	TT	Thrust Termination
MSIC	Missile Space Intelligence Center	UGCS	Unitary Guidance and Control Section
MTV	Maneuvering Target Vehicle	WSMR	White Sands Missile Range
NCU	Nozzle Control Unit		
NMD	National Missile Defense		

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